Professional Science Knowledge and its Impact on Confidence in the Teaching of Earth Science

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By

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ABSTRACT

This study focused on the nature and parameters of the relationships between the professional science knowledge of primary and intermediate teachers and their confidence in teaching in the *Making Sense of Planet Earth and Beyond* strand of *Science in the New Zealand Curriculum* (earth science). The study was divided into two phases of data collection. The first phase used a questionnaire survey of 18 teachers from the Taranaki, Wanganui, Manawatu, Palmerston North and Horowhenua districts of the western and central North Island of New Zealand. The survey identified the influence of the relationships between the participants' backgrounds in earth science, their professional knowledge frameworks and their efficacy to teach earth science. The second phase of data collection builds on the trends and common themes identified in phase one. Data were collected in the second phase through interviews of four teachers selected from phase one participants.

Analyses of the data collected revealed the importance of maintaining a well-developed understanding of the subject matter when teaching earth science. Subject matter knowledge has a notable impact in teachers' efficacy beliefs and ability to translate content into teachable material. Findings support pervious researchers' conclusion that teachers with high self-efficacy have had a long interest in science and a relatively strong background of formal science studies with opportunities for exploring science in informal settings. Results indicate that effective earth science teachers possess a genuine interest and enthusiasm for earth science. Conversely, teachers with relatively little earth science background display less developed knowledge frameworks and weaker efficacy beliefs. Common indicators of these weaknesses include avoidance of earth science topics in general or use of 'shallow' teaching strategies such as transmission approaches or 'resource based' units. In some cases it appears that teachers' confidence in their ability to teach earth science may be misplaced. Results indicate that in some cases, teachers can use their considerable classroom skills to avoid confronting earth science concepts where their knowledge is inadequate. The implications for these findings are considered.

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I would like to acknowledge the support of my family and friends, all of whom have weathered the storms and calms that are part and parcel of personal research. Their beliefs in my efficacy to complete this project sometimes exceeded my own and, no matter how difficult tasks seemed at times, spurred me on and provided much appreciated support.

I am indebted to the participants of this study, their willingness to participate and continue with the study. I continue to be impressed by their commitment and enthusiasm as members of the teaching profession.

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CHAPTER 1

INTRODUCTION

The study described in this thesis made an examination of the influences of primary and intermediate teachers' professional science knowledge frameworks on their confidence to teach earth science. The overall aim of this study is to investigate whether the knowledge teachers possess about earth science concepts and the teaching of earth science[1] has any influence on their feelings of efficacy in teaching earth science.

The current 'best practice' in science teaching is generally regarded as the use of constructivist teaching approaches with an emphasis on fostering students' conceptual development (Skamp, 1997). Such approaches place a great demand on teachers' professional knowledge frameworks. Also, the use of use these techniques requires a high level of belief that one can do so effectively.

Personal experiences, informal observations and anecdotal evidence suggest that in an effort to teach constructively, primary and intermediate teachers, often resort to watering down the content of science programmes. Such an occurrence is tragic from the science educator's perspective, but it is also understandable. Many primary and intermediate teachers are not science specialists and possess neither the knowledge, the confidence or the inclination to teach earth science when they would be far more comfortable teaching other subjects (Tilgner, 1990). Of these personal attributes, teachers' confidence has received the greatest amount of research attention.

Pre-service teacher education programmes generally address this lack of confidence by providing positive teaching experiences. However, in the personal experiences of the author these experiences rarely address earth science topics and often take place in artificial contexts that may actually trivialise the efficacy-building potential of these

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[1] For the purpose of this study, all material associated with the *Making Sense of Planet Earth and Beyond* strand of *Science in the New Zealand Curriculum* will be referred to as Earth science.

experiences. It is the author's belief that by bringing meaningful content back into primary science, and providing teachers with this content, or the means to access it, teachers will have more confidence to teach earth science effectively.

Background to the Study

Teacher confidence and competence in teaching science has long been an issue in New Zealand. After the first review of the implementation of *Science in the New Zealand Curriculum,* a report from the Education Review Office (1996) noted that many schools were identified as not covering all four of the contextual strands and the two integrating strands. The report also identified a tendency for primary schools to place greater emphasis on the contextual strand *Making Sense of the Living World,* while other strands, especially *Making Sense of the Physical World* and *Making Sense of the Material World* received much less attention.

"Expertise in teaching science" (Education Review Office, 1996, p. 22) and teacher confidence were reported to be "the most significant barriers to the successful implementation of *Science in the New Zealand Curriculum*" (ibid). Teachers cite "lack of knowledge, confidence and support" as a major factor.

The findings of the *Third International Mathematics and Science Study* (TIMSS) in 1994 revealed a disturbingly low level of science achievement by intermediate (Year 7 and 8) students as well as revealing concerns with the science programme level in general. The TIMMS data identified a wide variety of complex factors that could inhibit effective science programme implementation in New Zealand schools. Although many of these forces included external, system related components, it was inferred that the chief influencing factors related to teachers' knowledge, confidence and skill in implementing the science curriculum at classroom level.

Immediately following the release of TIMSS a ministerial taskforce for mathematics and science education identified teacher confidence and competence as major factors inhibiting effective programme delivery (Walker & Chamberlain, 1999). Similarly, a study by Lewthwaite (1999) found that "approximately half" (p.15) of primary and intermediate teachers consider that confidence was a problem in teaching science.

Along with issues of confidence, the TIMSS Revisited (TIMSS-R) asserted that effective science teaching depends on teachers having the subject matter knowledge and the professional training to maximise students' learning of the subject (Ministry of Education, 2001). No link between teacher knowledge and confidence was investigated.

earth science education has received very little systematic research either internationally, or within a New Zealand context. Vallender (1997) speculates that this reflects the status of earth sciences in school curricula or that very few geoscientists are involved in science education reform.

Much of the information regarding earth science education in New Zealand comes from research on science education in general. These sources, along with the few pieces of work on earth science itself, reveal that earth science is generally held in low regard when compared to the more traditional science disciplines (Vallender, 1997). The domain of earth science is generally misinterpreted (*ibid.*) and that the same problems of poor teacher confidence and knowledge exist in earth science as they do in other science disciplines. In some conceptual areas, such as the geological history of New Zealand or astronomy, poor teacher confidence and knowledge are even more of an issue than traditional 'hard' topics such as energy or electricity (Lewthwaite, 1999).

Rationale for the Study

The results of numerous research efforts have shown that teachers' professional knowledge and confidence are major issues in science education. However addressing these issues is not straightforward. In the wake of TIMMS, the Ministry of Education embarked on an ambitious programme to improve the implementation of *Science in the New Zealand Curriculum*. These efforts consisted largely of in-service professional development programmes and the development of teacher resource materials. These efforts were commendable, though for the most part, more effective rhetorically than professionally Lewthwaite (2001).

This study attempts to address the problems identified in studies such as TIMMS. It is by no means the intent of this study to solve such complex issues, but rather to identify the nature of the problems at hand so that they can then be more effectively addressed in the future.

The purpose of this study is to ascertain the nature of any relationship between the various types of knowledge that primary and intermediate teachers possess, and their confidence to teach programmes based in the *Making Sense of Planet Earth and Beyond*. If such a relationship does exist and is meaningful, it may be possible to build teachers' confidence in the teaching of earth science subjects through developing their professional science knowledge. Such development may include a broadening and deepening of earth science subject matter, effective teaching/explanatory strategies, useful learning activities, improving awareness of curricular requirements and resources, or any combination of similar professional knowledge requirements.

Significance of the Study

There is very little research in the areas of earth science in New Zealand schools and relationships between efficacy and knowledge structures. It is hoped that this study will provide valuable seminal data in these areas. Additionally, though it is not the intent of this study, the findings of this investigation may also have applications in other science education disciplines. It is anticipated that the findings of this study will be valuable to the teacher education community. It investigates two major factors in effective science

programme delivery. Any relationships found between these two areas may be of great use to those developing programmes to address these concerns in current and future primary and intermediate teachers.

This study may be significant internationally. The concerns of primary science education in New Zealand are similar internationally (Lewthwaite, 2001). The findings of this study may be of value to educators from other countries that are also attempting to improve the effectiveness of their own earth science programme delivery.

Outline of the Thesis

This Thesis is presented in seven chapters and additional appendices.

Chapter One details the background and reasons for the study. It considers the possible significance of the findings of the study. It outlines that aims, intentions and structure of the investigation and the thesis.

Chapter Two involves a review of the literature in fields relevant to the study. It considers (1) the history, structure and implementation of the New Zealand science curriculum as well as the place and implementation of earth science in New Zealand science education; (2) self-efficacy and it's influence of teaching and science teaching and (3) the dimensions and sources of professional science knowledge for teachers.

Chapter Three reviews the methodologies involved in the collection and interpretation of data in the study. It addresses the theoretical framework of the study and explains the authors' reasoning behind the data gathering techniques chosen and considers the methods used to analyse these data.

Chapter Four considers the data gathered in the first phase of data collection, the teacher survey. These data are analysed graphically and statistically using ANOVA and regression analyses. This chapter identifies commonly occurring trends and themes and makes some consideration in light of links with other relevant data and the work of previous researchers.

Chapter Five addresses the analysis of data gathered during the second phase of data collection, the teacher interviews. It considers teachers' responses and identifies commonly occurring themes in the light of results from phase one and existing research.

Chapter Six discusses the major findings of the study in the light of the findings of both phases of data collection and with due consideration to the findings of previous workers.

Chapter Seven reviews the processes involved in the execution of the study, considers the study's major findings and their significance. It discusses the implications of the limitations in the study methodology and implementation and makes recommendations for further research.

The appendices contain additional material that is pertinent to the study. It includes the survey used in phase one and the interview framework used in phase two. A thorough bibliography of the reference material used in the study is included.